Combustion and Oxidation

Look at these experiences with fire:

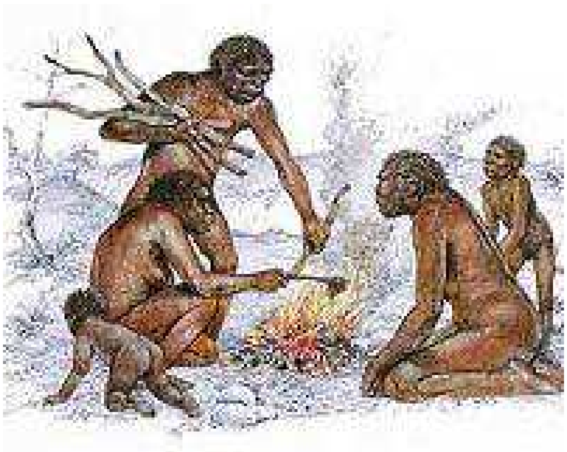
And now look at these:

Guess what is the difference between these sets of images? Write your answer in the box given.

As you may have guessed, the first set shows a controlled use of fire, whereas the other set shows fire getting uncontrolled, or disastrous.

Without fire, humanity may not have been what it is today. The discovery of fire completely transformed early humans living amidst the wild. Think of five things fire could have added to the lives of early humans.

We can say fire would have allowed them to cook, to see in the dark, to scare wild animals away, to warm themselves in cold, to clear large forests quickly by burning, to soften or melt hard and tough substances like metals, or bake things like clay etc.



There are some qualities of fire which make it so extremely useful, but **also** dangerous. Can you reflect on what these qualities are?

Fire is a source of large amounts of quick and concentrated energy, which can be generated and spread rather easily. The energy is mainly in the form of heat and light.

We can see that fire is a source of energy. But **what is fire**?

In the module on Living and non-living, we showed that fire is non-living. (Link to module on Living and non-living).

Click on the options that sound correct to you:

- Fire is pure energy and is not matter
- Fire is burning gases
- Fire is burning solids, liquids or gases
- Fire is heat and light
- Fire is a chemical reaction

Fire is actually a result of exothermic chemical reactions that happen when matter burns. All three phases of matter whether solid, liquid and gases can burn, e.g. wood, oil or hydrogen gas accompanied by release of energy in the form of heat, light and even sound.

Looking at burning

Think of the experiences below:

- We burn a candle.
- We burn oil in a lamp.
- We burn big logs of wood.

Think of all the things that you can see or feel getting produced as a result of burning in the above.

We see or feel the following things being produced: smell, vapour, smoke, heat, light, sound, ash.

What do you think gets finished or disappears after burning in the above situations?

We see the fuel, i.e. wax, wood or oil disappearing.

We burn wood and see it turning into ash and smoke. Suppose we burn 100 kg of wood, and get 3 kg of ash. Where has the 97 kg of matter gone?

Click on the option that you find correct:

- Most of the matter involved has been destroyed.
- Most of the matter got converted into another kind of matter.

Following the law of conservation of matter (link to matter chapter where law of conservation is discussed), all matter involved has changed into new compounds, through chemical reactions. The 97 kg of matter which is not visible now has actually turned into new, invisible gaseous compounds.

This is the surprising result which only very careful measurements can show, and is not realized ordinarily in daily life, because we cannot see most gases (except little as smoke).

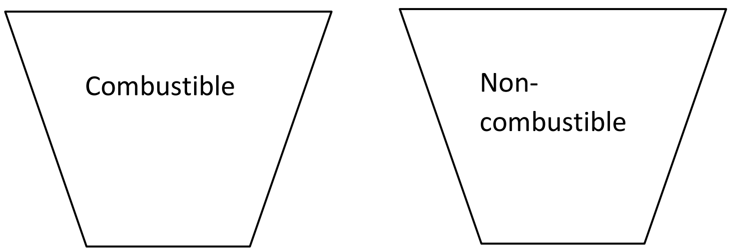
What is combustion?

Combustion is a chemical process in which a substance reacts with oxygen to produce other substance (or substances) and heat. In some cases, along with heat, light with flame or glow is also produced. In ordinary life, we call this burning.

Combustible and non-combustible substances

We see in daily life that many substances can burn easily, some burn with difficulty and some do not seem to burn at all. Those that burn easily are called **combustible** and those that don't are **non-combustible**. From the list below, can you separate substances into these two categories?

Iron nail, paper, straw, matchstick, stone, glass, charcoal, wool, mustard oil, oxygen, LPG (liquid petroleum gas), kerosene, cotton cloth, aluminium foil, nylon cloth, diesel, plastic, jute, rubber, oil-paint, asbestos, tile, clay, wheat-flour, groundnuts, bread



paper, straw, matchstick, charcoal, wool, mustard oil, LPG (liquid petroleum gas), kerosene, cotton cloth, nylon cloth, diesel, plastic, jute, rubber, oil-paint, wheat-flour, groundnuts, bread will go in the combustible bucket

whereas Iron nail, stone, glass, oxygen, asbestos, tile, clay will go in the non-combustible bucket.

The wrong answer is not accepted in a bucket.

Why is it that some materials will burn with great ease, some with difficulty, and some don't? Reflect for a moment and click next.

To answer this question we will have to look at what happens to substances at the physical level, but also at the chemical level, when they burn. This is what we are going to be looking at in the rest of this module.

When we heat wax, it melts into a liquid, and then vapourises (changes into a gas). Is this happening to wax in a burning candle?' **Agree/disagree**

Changing into liquid and to gas is simply change of state, and are **reversible physical** changes. If we collect wax vapours and cool them, we can get liquid and solid wax back again. But in a candle, wax is not just turning into vapours. The vapours are undergoing a **chemical reaction**, an irreversible chemical change. (link to module on physical and chemical change). We cannot get wax back after it is burnt.

Role of air in combustion

Humanity itself realized the nature of combustion after serious studies done by scientists, which were progressively refined. Large amount of matter is involved as invisible gases when combustion reactions happen. Invisible gases are ***used up*** from air along with the fuel as well as ***produced*** in these reactions.

Interesting fact: *Story of phlogiston: Prior to eighteenth century, the process of combustion was explained with the help of the theory of phlogiston. Phlogiston was supposed to be a fire like element which resided in materials in different quantities. In general, combustible substances were supposed to be rich in phlogiston. So burning of wood was supposed to be:*

Wood $\longrightarrow$ *ash + phlogiston (goes to air).*

However, Lavoisier discarded this theory in 18th century, when he showed that combustion and related processes were actually reactions in which oxygen combined with other substances.

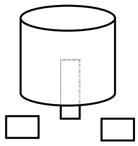
Looking at a candle

Fix a small lighted candle on a table. Cover it with an inverted glass tumbler. Alternatively, burn a candle inside a glass jar, and cover it with a lid.

What happens to the candle?

Yes, the candle goes off.

A. Now make a roll of card paper or newspaper. You have to stand in such a way so that you can see the candle inside. Put the candle inside the roll. Rest the roll on some wooden blocks or small inverted kitchen bowls as shown (Be careful as to not touch the roll with the flame). Observe what happens to the flame and write in the box.



The candle keeps burning freely.

B. Now remove the blocks and let the roll rest on the table. Do you see any difference to the flame? Write in the box below.

The flame becomes slightly unsteady.

Can you think of reasons for the difference in the flame in case A and B? What do you think can be possibly happening different in these cases?

Possibly, the lower opening provides an additional passage of air. If you want to check for this, bring a burning incense stick (giving off smoke) near the lower edge of the roll in situation A. When you bring it quite close, or take it inside where do you see smoke going? Does it give you a hint about the passage of air?

Yes, the passage of air is clearly from outside the roll to inside towards its upper end. This shows that the space under the roll provides a passage for air.

All experiences above show that a **continuous supply of air** seems essential for burning. Why is this so? Think and click next.

Lavoisier was the first person who showed with careful measurements, that when materials like sulphur and phosphorus were burnt in air, the weight of the product **increased after reaction.** This clearly showed that something **from air** actually contributed to burning, added additional weight, and created new compounds. This gas turned out to be **oxygen**, only one of the many components of air! It is oxygen in air that makes combustion possible, not all of air.

Interesting fact: *Joseph Priestley had found that if you heat mercury in air, you get a brick-red substance (they called it 'calx'. Today we know it as mercuric oxide).*

After this Priestley put this calx in a test tube and concentrated sunlight on it, to heat it. It broke down into mercury again, since shining globules appeared on top of the substance. But instead of normal air, an interesting gas came out. This gas did not burn by itself, but supported vigorous burning. When he put a glowing splinter into the tube, it burst into flame. Today we know that this is oxygen, one component of air, which would combine with mercury, when mercury is heated in air.

This is how Priestley discovered that oxygen was used up during the process of burning (a mouse put in the same jar as a burning candle is killed), but restored by photosynthesis (another mouse kept in a jar with a burning candle ***along with*** *a plant is able to live)!*

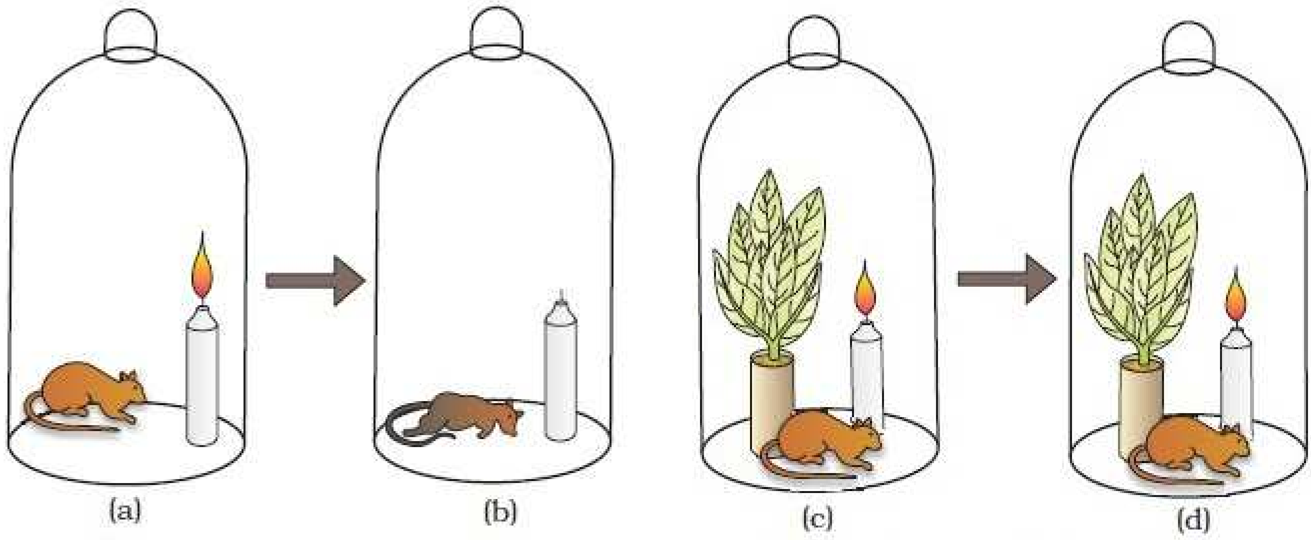


Figure 1. Priestley's experiment

Here is an experiment to measure the quantity of oxygen in air:

http://www.atmo.arizona.edu/students/courselinks/fall12/atmo170a1s1/coming_up/week_1/oxygen_conc_expt.html

Fun experiment: Generate oxygen yourself

Add a few drops of hydrogen peroxide to a ½ teaspoon of yeast in a test tube. (Hydrogen peroxide is often available in chemist shops, and yeast in grocery stores). Immediately ignite a small splint of wood and blow it out carefully after a few seconds so that the end is still glowing and hot. If you place this into the test tube, it would burst into flame. This is another illustration of oxygen supporting combustion.

Carbon-di-oxide as a product of combustion

Scientists also discovered that a gas called carbon-di-oxide was a product of combustion as well as breathing, though not always. If a flame was brought in this gas, it got extinguished. Now we know that whenever substances containing **carbon** would burn in oxygen, carbon-di-oxide would be produced.

Experiment: generate carbon-di-oxide

Cut off the top of a two-litre bottle and combine vinegar and baking soda in the bottom. Let the mixture bubble until the reaction is complete. Light a candle and lower it into the bottle. The candle will go out immediately once it is lowered into the bottle. The reaction of vinegar and baking soda has created large amounts of Carbon-di-oxide, removing all the oxygen from the area and extinguishing the candle.

Fun experiment: Inflating Balloons

Fill an empty bottle one-third of the way full with white vinegar. Next, pour baking soda into the bottle using a funnel. Quickly close the bottle with a balloon in place of the cap, and watch the fun as the balloon inflates!

How Nitrogen in air affects combustion?

Nitrogen is nearly 78% of air. It is an unreactive gas, and it is because of its presence that burning does not happen too fast. Oxygen is extremely reactive. If the atmosphere was mostly oxygen and not nitrogen, carbon on earth would ignite too easily and life would not be possible, except under the oceans. And when all carbon and other elements combined with oxygen burn then Carbon-di-oxide would fill the atmosphere, and life couldn't exist.

Interesting fact: *When a scientist named Black was experimenting with air that was left after burning, he found that it was not all carbon-di-oxide. When carbon di oxide was absorbed from the air using chemicals, some air was still left. This leftover did not support burning, a mouse would not live in it.*

Another scientist named Rutherford experimented with this left over air. He kept a mouse in a closed container till it died. Then he burned a candle in the same air till it could burn no longer. He then also burned phosphorus in it, till it would not burn any longer. Then the air was passed through a solution that could absorb carbon-di-oxide. The remaining air now did not support combustion and a mouse did not live in it. This was later named as Nitrogen.

Catching fire

Think of burning a paper, wood, coal, dry leaves, a gas stove, kerosene stove, oil-lamp…What do you always do to start a fire? Think and click next

Yes, we mostly have to bring another fire near the substance to start burning.

Have you ever seen cooking oil catching fire when a frying pan is kept for too long on a burning stove? It catches fire when it becomes too hot.

Why does the material not start burning by itself? Why is it necessary to bring another fire, or to make the material very hot? Think and click next.

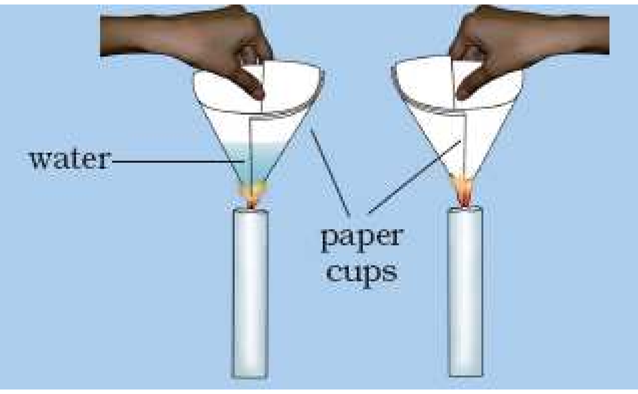
As can be seen, any material has to reach a certain temperature before the burning reaction with oxygen can start.

The lowest temperature at which a substance catches fire is called its **ignition temperature**.

We find that a combustible substance cannot catch fire or burn as long as its temperature is lower than its ignition temperature.

Paper not catching fire

Make two paper cups by folding a sheet of paper. Pour some water in one of the cups. Heat both the cups separately with a candle.



What happens to the empty paper cup? What happens to the paper cup with water?

Does water in this cup become hot?

If we continue heating the cup, we can even boil water in the paper cup.

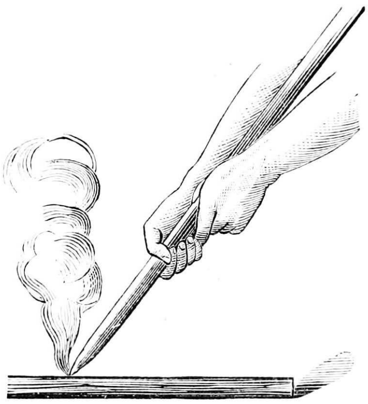
Can you think of an explanation for this phenomenon? Think and click next

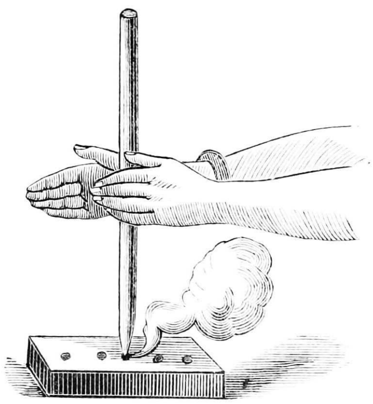
The heat supplied to the paper cup is transferred to water by conduction. So, in the presence of water, the ignition temperature of paper is not reached. Hence, it does not burn. It is essential for a substance to reach ignition temperature to burn

The substances which have very low ignition temperature and can easily catch fire with a flame are called **inflammable** substances. Examples of inflammable substances are petrol, alcohol, Liquefied Petroleum Gas (LPG), etc. Can you list some more inflammable substances?

Starting fire in other ways

How do people start fire when they do not have another fire (and no modern technology like matchboxes and lighters)? Think and click next.





We see above the ways in which aboriginals made fire, and some tribals or travellers still make it. The same methods are also used in some religious rituals. What do you think is creating fire in these situations?

As can be seen, it is heat generated by friction, though these methods are slow, difficult and require extreme patience and skill.

But even in the modern civilization we use the same principle to start a fire, though much more easily. Can you think where?

It is our common experience with a matchstick. We rub it to a rough surface to generate enough heat so that an easily combustible substance generates a spark.

Interesting fact: The safety match

The history of the matchstick is very old. More than five thousand years ago small pieces of pinewood dipped in sulphur were used as matches in ancient Egypt. The sulphur was the substance that caught fire easily.

The modern safety match was developed only about two hundred years ago. It is safe because it doesn't catch fire by itself. We have to strike the matchstick against a special surface to get it to ignite.

*The head of the safety match contains **antimony trisulphide** or **sulphur**. These are substances that burn easily. Along with this, **Potassium chlorate** is added which can supply oxygen.*

*The rubbing surface has powdered glass and a little **red phosphorus.***

When the match is struck against the rubbing surface, the glass powder on both surface gives enough friction to generate heat. The heat converts a small amount of red phosphorus to white phosphorus vapour. This immediately burns with the heat, reacts with potassium chlorate which releases oxygen. This produces enough heat to ignite antimony trisulphide/sulphur and start the combustion.

Slow combustion (rusting)

You must have observed that iron articles are shiny when new, but get coated with a reddish brown powder when left for some time. This process is commonly known as **rusting** of iron.

Let us test different substances to see which will show rusting.

What causes rusting?

Rusting happens because of combination with oxygen in the atmosphere. Iron turns into iron oxide as a result of this combination.

http://s.hswstatic.com/gif/rusty-nail-tetanus-1.jpg

We notice that rusting happens faster when there is moisture (or some other substances) present. This is because water, vinegar etc. may act as ***catalysts*** for the reaction. (Catalysts are substances that increase the rate of a reaction but do not participate in the reaction. Each chemical reaction can have different catalysts).

Copper also turns into copper oxide in the atmosphere, as we can see in copper coins.

http://nobel.scas.bcit.ca/wiki/images/3/31/Penny.jpg

However, we often see a green coating on copper surfaces left in air and moisture. This is because of formation of green copper carbonate.

http://www.nachi.org/forum/attachments/f22/15258d1192588373-green-crystallized-matter-copper-pipe-dsc06365.jpg

Respiration is also slow combustion

In 1783, Lavoisier and Laplace, tried to carefully measure the amount of heat and carbon-di-oxide given out by a live guinea pig, closed inside a container. They compared this to heat given out when the same amount of carbon-di-oxide was produced by burning carbon. When they found that both were exactly the same, they concluded that respiration was a slow form of combustion.

Flame

Look at the three cases of burning above. Why do we see a flame in two cases and not in one case? Think and click next.

In some cases of burning, the burning materials vaporise during burning, hence a flame is produced. For example, kerosene oil and molten wax rise through the wick and are vaporised during burning and form flames. Charcoal, on the other hand, does not vaporise and so does not produce a flame.

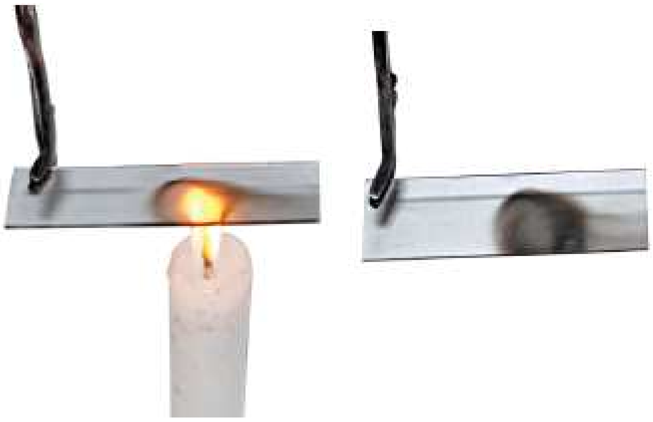
Fun experiments with flames!

Light a candle. Hold a glass tube with a pair of tongs and introduce its one end in the dark zone of a non-flickering candle flame. Bring a lighted matchstick near the other end of the glass tube. Do you see a flame?

What is it that produces a flame? Think and click next.

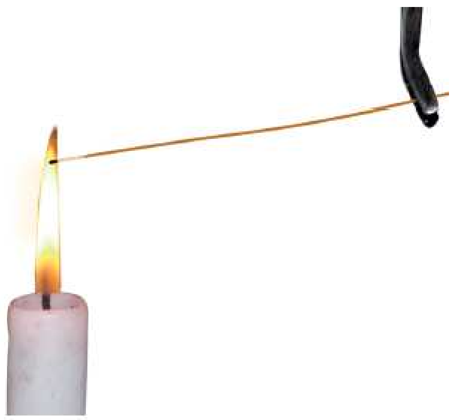
The wax near the heated wick melts and then vaporises quickly. The glass tube catches these vapours and they burn at the other end of the tube.

When the candle flame is steady, introduce a clean glass plate/slide into the luminous zone of the flame. Hold it there with a pair of tongs for about 10 seconds, then remove. What do you observe?



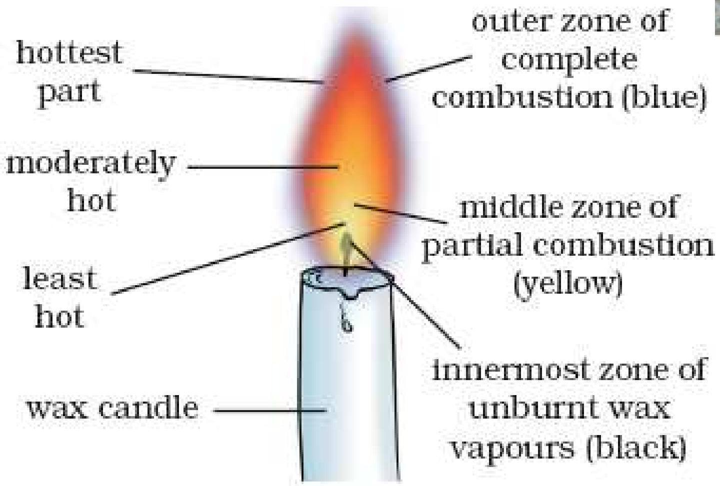
A circular blackish ring is formed on the glass plate/slide. It indicates the deposition of unburnt carbon particles present in the luminous zone of the flame.

Hold a thin long copper wire just inside the flame for about 30 seconds. What happens?



The portion of the copper wire just outside the flame gets red hot. It indicates that the non-luminous zone of the flame has a high temperature. In fact, this part of the flame is the hottest part.

Interesting fact: Goldsmiths blow the outermost zone of a flame with a metallic blow-pipe for melting gold and silver.



Coloured Flame

Why do you think that fire has different colours in the situations above?

Most people think fire is yellow, because they have seen wood burning. Most woods contain sodium, which produces a yellow flame.

If you sprinkle salt on a blue flame (of gas stoves), you will see the flame change colour, because ordinary salt is sodium chloride.

Different chemicals present in the burning substance change the colour of the flame. For example, borax, which can be purchased at medical stores, will burn with a light green colour. Potassium chloride will produce a purple colour.

Complete Combustion

Ignite a gas stove so that you get a good blue flame. Now sprinkle just a little water over the flame. What happens?

Yes, the flame becomes yellow.

The hot blue flame is produced when there is adequate oxygen for the gas to undergo complete combustion. The cooler yellow flame is a product of incomplete combustion.

Result of Incomplete Combustion

Allow a china porcelain plate or dish above a hot blue flame for a few seconds. Be careful not to burn your hands in the process. Notice if anything deposits over the plate.

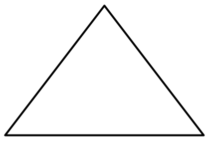
Now take a yellow flame of a candle and bring the plate above for a few seconds. What do you observe?

The less hot flame gives a black spot on the dish. The hot blue flame gives little or no accumulation of black soot. The blue flame is undergoing complete combustion. Every carbon atom in the fuel supply finds two oxygen atoms to combine with to form CO_2. But when oxygen is limited, some carbon accumulates on the dish rather than being completely converted to CO_2.

Controlling fire

There are **three** essential requirements for producing fire. Can you guess what these are?

Combustion reactions require these three things: **oxygen, heat** and **fuel**, which create what is known as the fire triangle.



Can you think of why each of these is essential? Think and click next.

The fuel itself burns; oxygen for combustion is obtained from air and heat is required to raise the temperature of the fuel upto the ignition temperature.

Fire can be controlled by removing one or more of these requirements. The job of a fire extinguisher is to cut off the supply of air, or to bring down the temperature of the fuel, or both. Notice that the fuel in most cases cannot be eliminated. If, for instance, a building catches fire, the whole building is the fuel.

Suppose a person's clothes catch fire. Often, one immediate action is to wrap the person in a blanket. What causes the burning to stop? Think and click next.

Yes, the air supply has been cut off to stop burning.

The most common fire extinguisher is water. It cools the burning substance, and its vapours surround the fuel, cutting off air supply. But water works only when things like wood and paper are on fire. If electrical equipment is on fire, water can be dangerous. Can you guess why? Think and click next.

Water may conduct electricity and harm those trying to douse the fire.

Water is also not suitable for fires involving oil and petrol. Do you recall that water is heavier than oil? So, it sinks below the oil, and oil keeps burning on top.

For fires involving electrical equipment and inflammable materials like petrol, Carbon-di-oxide (CO_2) is the best extinguisher. CO_2, being heavier than oxygen, covers the fire like a blanket. Since the contact between the fuel and oxygen is cut off, the fire is controlled. The added advantage of CO_2 is that in most cases it does not harm the electrical equipment.

How do we get the supply of Carbon-di-oxide?

A gas can be converted to liquid by putting high pressure over it, forcing its particles to come closer. Then it can be stored as a liquid in cylinders. When released from the cylinder, CO_2 expands enormously in volume to become gas again, and cools down.

So, this cool CO_2 not only forms a blanket around the fire, it also brings down the temperature of the fuel. That is why it is an excellent fire extinguisher. Another way to get CO_2 is to release a lot of dry powder of chemicals like sodium bicarbonate (baking soda) or potassium bicarbonate. Near the fire, these chemicals give off CO_2.

Fun experiment: Money Burn

Combine water and alcohol to create a mixture in which to dip a 10 rupee note or some stiff paper. The proper ratio of water to alcohol differs based on what type and concentration of alcohol you use. Dip the rupee into the liquid with kitchen tongs and squeeze out the excess. Holding it with the tongs, light it at the bottom. The alcohol burns at a lower temperature than the rupee. The water helps keep the temperature from reaching the combustion threshold of the note by evaporating off. If this is conducted correctly, you will be left with a damp rupee.

Fun experiment: vanishing flame

Light a candle. Take a fine steel wire tea-strainer (*chhanni*) and place it over the top of the flame. The flame cannot cross the mesh, and if you lower it enough, the flame goes out. Why do you think this happens? Think and click next.

The mesh distributes the heat over the strainer, removing heat from the flame and causing it to go out.

Fuels

Commonly used sources of heat energy are called fuels. What qualities would make a good fuel? Write in the box given below.

A good fuel is one which is: readily available, is cheap, burns easily in air at a moderate rate and produces a large amount of heat. It does not leave behind any undesirable substances.

Fuel Efficiency

Suppose you need to boil 30 kg of water using cow dung, coal and LPG as fuel. Which fuel would you prefer? How would you decide? Think and click next.

Do these three fuels produce the same amount of heat?

The amount of heat energy produced on complete combustion of 1 kg of a fuel is called its calorific value. The calorific value of a fuel is expressed in a unit called kilojoule per kg (kJ/kg). Calorific values of some fuels are given in the Table below.

Fuel	Calorific Value (kJ/kg)
Cow dung cake	6000-8000
Wood	17000-22000
Coal	25000-30000
Petrol	45000
Kerosene	45000
Diesel	45000
Methane	50000
CNG	50000
LPG	49000 (approximate)
Biogas	35000-40000
Hydrogen	150000

What makes certain things to give out more heat energy?

Seeing the table, it is easy to see that hydrogen gives very high quantity of heat upon burning with oxygen. So **greater the proportion of hydrogen** in a fuel, the more calorific value it will have. e.g. in the hydrocarbons (compounds of hydrogen and carbon only), methane has highest calorific value.

Wood is largely carbohydrates, which have carbon, hydrogen and oxygen. Oxygen supports combustion, but does not burn itself, so anything having additional oxygen will have lesser calorific value as compared to hydrocarbons.

Harmful products of combustion

Imagine standing in front of wood burning which is giving out a lot of smoke. What is the effect on you? Reflect for a moment and click next.

Burning wood gives a lot of smoke which is very harmful for us. It causes respiratory problem. Carbon fuels like wood, coal, petroleum release un-burnt carbon particles and many other substances which cause burning of eyes. These fine particles are dangerous pollutants causing respiratory diseases, such as asthma.

Incomplete combustion of these fuels gives carbon monoxide gas. It is a very poisonous gas. It is dangerous to burn coal in a closed room. The carbon monoxide gas produced can kill persons sleeping in that room.

How can we reduce the effect of these products of combustion on us? Reflect for a moment and click next.

Chimneys take away the products of combustion and that is why they are recommended in living places.

Large scale effects of combustion products

Humans burn a lot of fuels for a variety of uses. Can you think of a few, other than your home?

Humans burn fuels in factories, boilers, engines or power plants running on coal or petrol products, for heating buildings etc.

Reflect for a moment on the effects of large scale burning on the environment, and click next.

Combustion of most fuels releases Carbon-di-oxide in the environment. Increased concentration of Carbon-di-oxide in the air is believed to cause global warming. Global warming is the rise in temperature of the atmosphere of the earth. This has many worrisome effects like the melting of polar glaciers, which leads to a rise in the sea level, causing floods in the coastal areas. Low lying coastal areas may even be permanently submerged under water.

Other gases that are produced due to burning of fuels have large scale effects too. Burning of coal and diesel releases sulphur dioxide gas. It is an extremely suffocating and corrosive gas. Moreover, petrol engines give off gaseous oxides of nitrogen. Oxides of sulphur and nitrogen

dissolve in rain water and form acids. Such rain is called acid rain. It is very harmful for crops, buildings and soil.

Can you think of an example of a fuel with lesser environmental damage?

The use of diesel and petrol as fuels in automobiles is being replaced by CNG (Compressed Natural Gas), because CNG produces the harmful products in very small amounts. CNG is a cleaner fuel.

Oxidation and Reduction reactions

Oxygen is a highly reactive gas, and available in the atmosphere in plenty. So it is hardly surprising that a large number of elements found on earth combined with oxygen to form oxides.

Suppose we heat a china dish containing some copper powder. What do we observe? The surface of copper powder becomes coated with black copper oxide. The oxygen in air reacts with copper to form copper oxide.

$2Cu + O_2 \longrightarrow 2CuO$

If hydrogen gas is passed over this heated material (CuO), the black coating on the surface turns brown as the reverse reaction takes place and copper is obtained.

$CuO + H_2 \longrightarrow Cu + H_2O$

If an element gains oxygen during a reaction, it is said to be **oxidised**. If an element loses oxygen during a reaction, it is said to be **reduced**.

During this reaction, (click on the option you choose)

Copper is **Oxidised/Reduced** Reduced

Hydrogen is **Oxidised/Reduced** Oxidised

In other words, one element in reactants gets oxidised while the other gets reduced during a reaction. Such reactions are called ***oxidation-reduction*** reactions or ***redox*** reactions.

Importance of these reactions

It was due to the importance of reaction with oxygen that scientists had named these reactions as oxidation reactions. Later on, removal of hydrogen from a substance was also termed as oxidation.

$2HCl + Zn \longrightarrow ZnCl_2 + H_2$

Click on the option you choose:

Here, Chlorine gets **Oxidised/Reduced**

Oxidised

Later on, the definition of oxidation based on the addition of oxygen was extended for addition of other electronegative elements such as fluorine, chlorine, bromine and sulphur also.

e.g. $Mg + Cl_2 = MgCl_2$

Here Magnesium is getting oxidised because of addition of chlorine.

Notice that Magnesium is losing two electrons here to turn into positively charged magnesium ion. At the same time chlorine is pulling electrons from Magnesium to become negatively charged chloride ion. They are both completing their outermost orbits to form bonds in such reactions. (link to module Matter2)

$$Mg \xrightarrow{-2e^-} Mg^{2+}$$

$$2\ Cl \xrightarrow{+2e^-} 2\ Cl^{2-}$$

Since magnesium is losing electrons when getting oxidised (in combining with chlorine or oxygen etc.), the definition of oxidation was extended to ***loss of electrons by some atom or ion.***

Reduction

Similarly, the related term reduction was initially introduced when oxides were converted to metals by their reaction with hydrogen or carbon.

$CuO + H_2 \quad = \quad Cu + H_2O$

In this reaction, the copper ion accepts or ***gains*** electrons to become copper atom. Hence it is ***reduced.***

$$Cu^{2+} \xrightarrow{+2e^-} Cu$$

Thus,

Loss of electrons by an atom/ion = oxidation.

Gain of electron by an atom/ion = reduction.

Consider the following reaction:

Zn + Cu SO4 → ZnSO4 + Cu

Zn neutral atom gains/loses loses electrons to become zinc ion and is therefore oxidised/reduced oxidised

Cu ion gains/loses gains electrons to become neutral copper atom and is therefore oxidised/reduced reduced

A large number of chemical and biological processes are redox reactions like photosynthesis, respiration, corrosion of metals etc.

Is all oxidation combustion?

We have described combustion as a reaction where the burning substance is combining with oxygen, hence it is necessarily a redox reaction. But for something to be called combustion, ***heat and light*** have to be given out. This means the reaction will have to be exothermic (giving out energy).

However, all reactions with oxygen may not be exothermic like combustion e.g. in rusting copper and iron do not burn, though they react with oxygen too.

Rancidity as a result of oxidation

Have you ever tasted or smelt the fat/oil contained in food materials left for a long time?

When fats and oils are oxidised, they become rancid and their smell and taste change. Usually substances which prevent oxidation (antioxidants) are added to foods containing fats and oil. Keeping food in air tight containers helps to slow down oxidation. Chips manufacturers usually fill packets of chips with gas such as nitrogen to prevent chips from getting oxidised.

Reference sites:

For images:

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